

Name	Date started	Target end date
------	--------------	-----------------

GCE AS / A LEVEL – DIFFRACTION GRATINGS QUESTION PACK

Legacy PH2 · New spec Unit 2 Topic 5b · AS unit, 20% of A-level

REVISE

.wales

PHYSICS – UNIT 2 · DIFFRACTION GRATINGS

PH2.5 Wave properties – diffraction gratings & resolving spectra

Applying $d \sin \theta = n \lambda$ to transmission gratings, calculating angles for multiple orders, and interpreting spectra produced by white-light and discrete-line sources.

NEW 2015 SPEC · UNIT 2 TOPIC 5B

Estimated time for entire question pack: ~1 h 18 min

Derived from the legacy PH2 paper's pace of 80 marks in 1¼ hours.

You are advised to **not** attempt to complete all of this in one sitting.

ABOUT THIS QUESTION PACK

This is a **comprehensive practice question pack**, not a single mock paper. It contains every question from the legacy WJEC PH2 papers (2008 modular spec) that maps onto new-spec Unit 2 Topic 5b (2.5).

Questions are ordered chronologically within each section.

INSTRUCTIONS

Use black ink or black ball-point pen. Answer all questions in the spaces provided.

The number of marks is given in brackets at the end of each question or part-question. A calculator is required.

The Data Booklet is allowed.

All question content is © WJEC CBAC Ltd. and reproduced for revision purposes.

For Examiner's use only

Q	Source	Max	Mark	Q	Source	Max	Mark
7	PH2 Jun 15 Q2	7		10	PH2 Jan 10 Q2	14	
8	PH2 Jan 11 Q3	8		11	PH2 Jun 16 Q1	18	
9	PH2 Jun 14 Q3	9					
						Total	56

Diffraction Gratings – what the new spec asks

WJEC GCE AS / A Level Physics (from 2015) · Unit 2: Electricity & Light · Topic 2.5.

Grating equation A

- Apply $d \sin\theta = n\lambda$ for transmission gratings.
- Identify d from lines-per-mm.
- Calculate maximum observable order from $\sin\theta \leq 1$.

Spectra A

- White-light spectrum vs. discrete-line spectrum.
- Why higher orders are increasingly dispersed.

Resolving power A

- Effect of more lines per unit length on sharpness.
- Compare grating to a Young's double-slit pattern.

Diffraction Gratings in one page

Quick-reference notes – revisit before each section.

Grating equation

d = line spacing = $1/(\text{lines per metre})$.

n = order (integer, including 0).

Solve for θ or λ as needed.

Max order

$n_{\text{max}} = \text{floor}(d/\lambda)$.

Always check this before reporting an order!

Spectra

Each λ diffracted to a slightly different angle.

Red diffracts more than violet ($n \times \lambda$ bigger).

Higher orders increasingly spread out.

Resolving power

More lines per mm \Rightarrow smaller $d \Rightarrow$ larger angles.

Sharper, narrower maxima.

Strategy

1. Find d from lines per mm.

2. Apply $d \sin\theta = n\lambda$.

3. If asked for n_{max} , use $\sin\theta = 1$.

Watch out for

If grating is "500 lines per mm" $\Rightarrow d = 1/(500 \times 1000)$ m.

Angle is from the central beam, not from the grating surface.

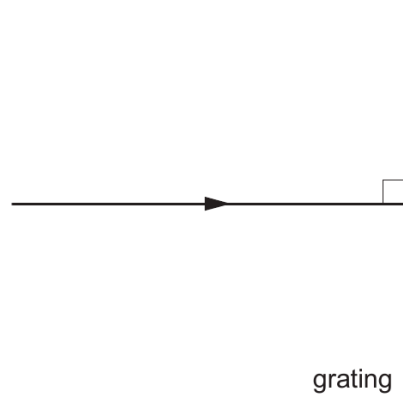
Section index

Use this index to jump straight to the section you need.

Section	Questions	Marks
A Gratings & spectra	Qs 7–11	56 marks

2. (a) A beam of light of wavelength 532 nm is shone normally (in the direction shown) on to a diffraction grating with slit spacing 1 200 nm (between centres of adjacent slits).

Examiner only



- (i) Calculate all the angles at which bright beams emerge from the grating. [3]

.....

.....

.....

.....

.....

- (ii) Draw all the emerging beams (representing each as a single line) **on the diagram above**. [You are not expected to use a protractor.] [2]

- (b) Light of wavelength 650 nm is now used instead of the light of wavelength 532 nm. State the ways in which the pattern of emerging beams will change. [You may wish to make further calculations.] [2]

.....

.....

.....

.....

.....

3. (a) The label indicating slit separation on a *diffraction grating* has been removed. A student decides to determine the slit separation (the separation between the centres of its slits) by shining a laser normally at the grating. The wavelength of the laser light is 5.32×10^{-7} m.

He measures the angle between a *second order* emerging beam and the central (*zero order*) beam to be 28.9° .

(i) Show clearly that the slit separation is approximately 2×10^{-6} m. [3]

.....

.....

.....

.....

(ii) Suggest an advantage of choosing a second order, rather than a first order, beam. [1]

.....

.....

(b) The student now uses the grating to determine the wavelength of the light from another laser. He measures the second order beam to be at an angle of 35.1° .

(i) Calculate the wavelength of the light. [2]

.....

.....

.....

(ii) Determine the highest order that the grating will produce with this wavelength. Show your working. [2]

.....

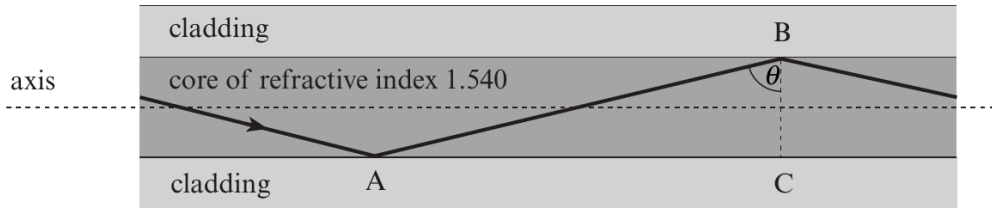
.....

.....

.....

.....

4. The diagram shows a path which light can take along a ‘thick’ (multimode) optical fibre.



(a) The smallest angle θ at which total internal reflection can take place is 77° . Calculate the refractive index of the cladding. [2]

.....

.....

.....

.....

(b) (i) Calculate the time it takes light to travel along 2.0 km of the fibre if it travels through the core in a straight line parallel to the axis of the fibre. [3]

.....

.....

.....

(ii) (I) Show that for $\theta = 77^\circ$, the length of AB is 1.026 times greater than the length of AC (see diagram). [1]

.....

.....

(II) Hence calculate the extra time it takes for light to travel 2.0 km along the fibre via the zigzag path (i.e. for $\theta = 77^\circ$). [2]

.....

.....

.....

(iii) Without further calculation explain how this difference in times limits the rate at which data (encoded in the light) can be sent through 2.0 km of the fibre. [2]

.....

.....

.....

3. (a) Describe a diffraction grating.

[2]

Examiner
only

.....

.....

.....

(b) A diffraction grating has 400 000 slits per metre of its width.

(i) Show that the distance between the centres of neighbouring slits is $2.5\mu\text{m}$.

[1]

.....

.....

(ii) A laser beam is shone normally at the grating. The **second** order beams leave the grating at angles of 25.2° either side of the grating normal. Calculate the wavelength of the laser light.

[3]

.....

.....

.....

(iii) Calculate the angle (to the grating normal) of the **third** order beams.

[2]

.....

.....

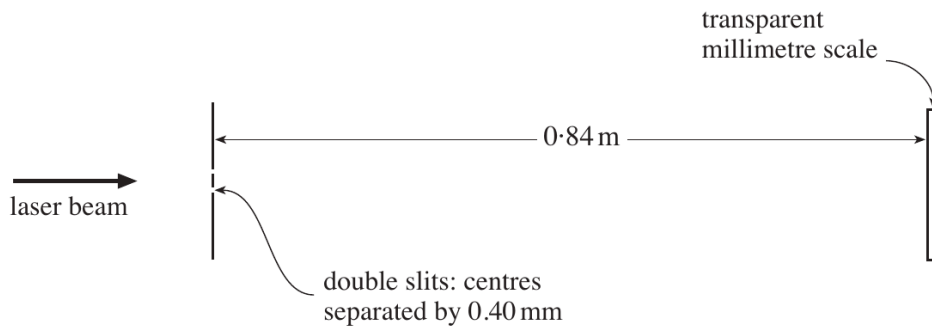
(iv) The beams of different orders are spaced much further apart than the fringes in a typical Young's slits set-up using the same laser. Why is this so?

[1]

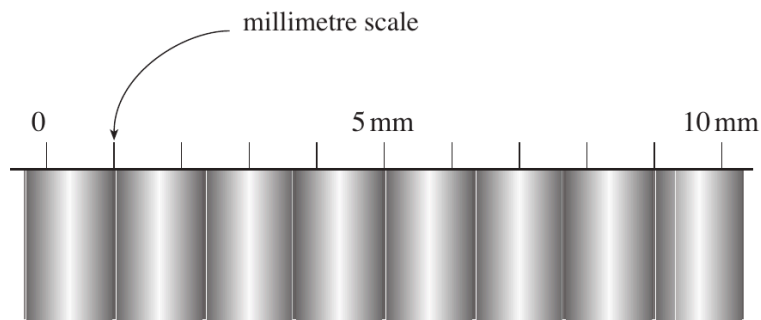
.....

.....

2. (a) Young's fringes are produced using light from a laser.



A transparent millimetre scale is placed 0.84 m from the double slits, as shown. When a camera is used to take a close-up picture of the scale, a series of equally-spaced bright and dark fringes is seen, as shown in the diagram below.



- (i) Explain, in terms of *interference*, *phase* and *path difference*, how the **bright** fringes arise. [4]

.....

.....

.....

.....

.....

.....

.....

- (ii) Using data from the diagrams calculate the wavelength of the light. [3]

.....

.....

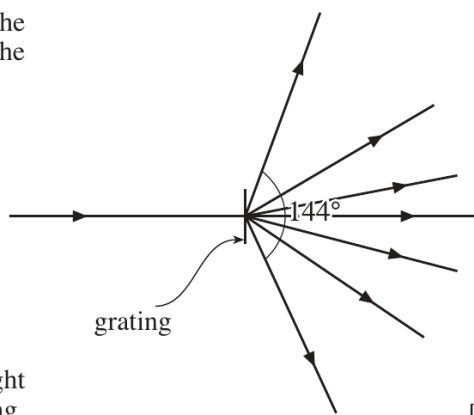
.....

(b) The laser beam is now shone normally (i.e. at 90°) at a diffraction grating with 5.00×10^5 'slits' per metre of length.

(i) Calculate the separation of the centres of adjacent slits in the grating. [1]

.....
.....
.....

(ii) Seven beams emerge from the grating. The central lines of the beams are shown in the diagram.



Calculate the wavelength of the laser light using the angle given. Show your working. [4]

.....
.....
.....
.....
.....
.....

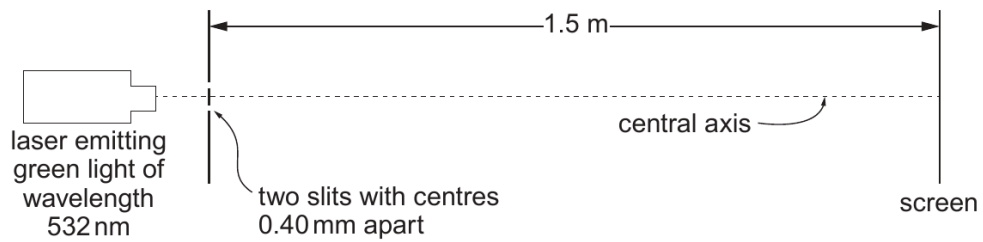
(c) Suppose that you have to make your own measurements to find the wavelength of light from a laser. Discuss whether you would choose the Young's fringes method, or the diffraction grating method, if you wanted an accurate value for the wavelength. [2]

.....
.....
.....
.....
.....

Answer **all** questions.

Examiner only

1. (a) A modern version of Young's double slit experiment is set up as shown.



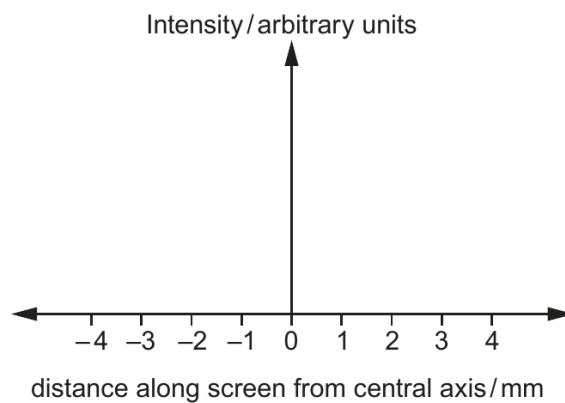
- (i) Calculate the fringe separation. [2]

.....

.....

.....

- (ii) Assuming that there is a bright fringe on the central axis, sketch below a graph of light intensity against distance from the central axis. [3]



- (iii) State **two** ways in which the pattern will change if the screen is brought closer to the slits. [2]

.....

.....

Examiner only

(iv) **Explain** what would happen if the following changes were made, individually.

I. A red laser is used instead of a green laser. [1]

.....

.....

II. One of the slits is blocked up. [2]

.....

.....

.....

(b) Green light from the laser is now shone normally on to a diffraction grating. The centres of the slits are 1500nm apart. **Second order** beams are observed at $45^\circ \pm 1^\circ$ to the normal. Calculate maximum and minimum values for the wavelength according to these readings. [3]

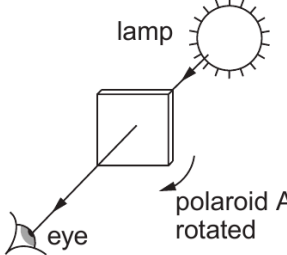
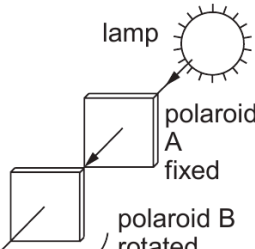
.....

.....

.....

.....

(c) Light from a filament lamp behaves like an *unpolarised, transverse* wave. This can be shown using polarising filters (*polaroids*). Two experiments are carried out as described briefly in the first column of the table below. In the second column state what is observed and, in the third column, give a brief explanation of what is observed. [5]

What is done	What is observed	Explanation
 <p>lamp</p> <p>eye</p> <p>polaroid A rotated</p>	<p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p>	<p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p>
 <p>lamp</p> <p>polaroid A fixed</p> <p>polaroid B rotated</p>	<p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p>	<p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p>

END OF QUESTION PACK

5 questions · 56 marks · ~1 h 18 min

Source: WJEC PH2 (2008 modular spec)

Curated for WJEC Physics 2015 spec AS Unit 2 – Topic 5b (2.5)

© WJEC CBAC Ltd. Pack layout © revise.wales for revision purposes only.